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TECHNOLOGICAL CHANGE, IMPERFECT MARKETS,AND AGRICULTURAL EXTENSION: AN OVERVIEW

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Technological Change, Imperfect Markets, and Agricultural Extension: An Overview

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It has long been recognized that the adoption of more productive technology is facilitated by a complex institutional framework, including property rights, credit and insurance markets, and extension services.[1] The two theoretical chapters in this Part illustrate the influence of market failures for water and risk on farmers' decisions regarding technology and outputs. The case study by Feder and Slade considers how best to organize an agricultural extension service.

The relationship between technology and rural institutions also runs in the opposite direction. In particular, technological change can widen the scope of markets. Aspects of rural organization which appear to be constraints -- e.g. indigenous land rights systems or missing markets -- may reflect the underlying technological possibilities and vanish when technology changes. Migot-Adholla et al. [14] provided evidence of cases in which the introduction of export crops, by increasing the scarcity value of land, induced changes in African indigenous land rights systems that made land markets possible. McIntire's case study below [27] argues that

[1]See,e.g. Ruttan 1982, Feder, Just and Zilberman 1985, and Thirtle and Ruttan 1987.

in arid pastoral environments in Africa, high transaction costs of trade preclude conventional markets for most goods, with the result that policies directed at providing credit or otherwise widening the scope of markets have been *mis*directed; the binding constraint depended on the technology.

The remainder of this section highlights some of the diverse issues raised in this Part: water rights, technological determinants of the scope of markets, agricultural extension, and inequality.

Property rights regimes in water

Whether farmers face correct incentives in their choice of technology depends on property rights regimes. In many parts of developing countries and also in much of the western United States, the rights regime with respect to surface water used for agriculture is essentially a queuing system, not a price system: Owners of senior rights can use as much water as they can put to beneficial use. Owners of junior rights get whatever is left over. Trading is prohibited.[2] Under this system, profit-maximizing farmers on lands with senior rights apply water until its marginal product is zero, while some lands with junior rights go unused for lack of water. It is evident that farmers with senior rights have little incentive to

[2]This system is known as the "prior appropriation" doctrine in the U.S. and by other names elsewhere. See the references in Shah et al. [25], note 2, regarding that doctrine in developing countries. In the U.S., the doctrine of prior appropriation was developed in California gold mining communities during the mid-19th century Gold Rush, and spread throughout the western U.S. as miners, irrigators, and herders took possession of the public domain before territorial governments were organized. Territorial and state governments later adopted and transformed this doctrine in administrative law governing water used for irrigation (see Cuzan, 1983, pp.17-19). In California, legal barriers to market transfers of water exist at the irrigation company level, at the state level in laws protecting areas of origin of water supplies, and at the federal level in reclamation law (Gardner, 1983).

adopt water-saving irrigation technology.

The theoretical chapter by Shah et al. [25], after providing a model of farmers' choice of irrigation technology, suggest a politically feasible method to create a water market to solve the water management problem--namely, to provide owners of senior rights in the initial property rights regime with a large share of the profits from the water utility created to implement the market. Their chapter sets forth a method of calculating the benefits of creating a market for surface water, and illustrates it with data from cotton farms in the San Joaquin valley, California. In that region, the estimated benefits of implementing a water market would be a 19 percent increase in aggregate incomes (not counting the costs of implementing the market).

In some cases, implementing a water market may be the first-best policy for water allocation. In other cases, there are very simple low-cost alternatives to implementing a market. A striking example comes from E.R. Leach's (1961) study of a village in the former Ceylon. In the village of Pul Eliya,

> Land rights to the rice fields were traditionally parceled out in such a way that the owner of the plot closest to the tank also owned the plot furthest from the tank; the second closest was paired with the second furthest, etc. If an owner wanted to sell all or part of his land, he could do so only by selling equal parts of both plots. The result was an incentive for good water management. When the British opened a new tank in the village without using the local system, the wealthier people simply acquired rights to the lands closest to the new irrigation source. The lands located furthest from the new tank were cultivated by lower-income farmers whose fields often did not receive water (since the farmers with lands nearer the tank used all the water).[3]

In this example, the practical difficulties of rationing water from a water

[3] We are indebted to an anonymous referee for this example.

tank were avoided by regulating property rights to land, its complementary resource.

Technology as a constraint on the scope of markets

Market failures may arise from the intrinsic physical characteristics of goods or technology, as has long been understood for commodities with public good properties (e.g., water in aquifers from which exclusion is difficult). But there are other ways in which technology and physical conditions limit the scope of markets. Traders of highly perishable goods may incur high costs and risks from loss. The services of factors, such as farm animals, that require regular care cannot readily be rented if they require constant care and the quality of care is difficult to monitor.

The first case study, by McIntire, explores the consequences for factor markets of a particularly harsh physical environment -- the arid regions of Africa where people earn their living from livestock production. No conventional markets for labor, land or capital exist there. Nonstorability of milk encourages self-sufficiency. High transportation costs preclude an active labor market. Credit transactions are limited because the main form of wealth -- animals -- is not useful as collateral because animals can be consumed and, in any case, their value depends greatly on the level of care provided. The difficulty of observing the quality of animals precludes an active market in animal stock. Instead of conventional markets, a complex network of family obligations and contracts allocates factors. For example, a form of animal tenure exists through which breeding stock are loaned from one herdsman to another with rental payments in the form of a share of offspring; by linking the tenant's income to the stock as well as the calves, this arrangement lowers supervision costs.[4]

In general, technological progress entails not only increases in outputs, but also changes that reduce the transaction costs of trade. For example, increases in the storability of outputs have been a key to the expansion of exports by many LDCs (e.g. Chilean grapes). Economists have only begun to consider how to model technology in ways that take into account the effect of modern inputs in increasing quality and uniformity, lowering storage costs and susceptibility to damage, or in other ways reducing the costs of trade (see Zilberman 1989).

Research and extension

Agricultural technology is highly location-specific. What works well in one place may not do so in another that is characterized by different climate, soils, access to inputs and markets, and culturally specific practices among the rural population. To deal with location specificity, it is necessary to undertake testing and transfer activities across the whole range of environments in which a new technology might be used.

Agricultural research and information services will normally be undersupplied in the private market. Information has public good properties. Moreover, farms are often too small and sell in markets that are too competitive to capture positive returns to R&D through their own sales. Until recently legal systems of intellectual property rights (patents, copyrights, and trademarks) did not cover plant and animal

[4]Robertson's (1987, p. 156-157) study of share contracting in breeding stock in Lesotho describes a similar practice.

improvements.[5] To make up for the undersupply of R&D by the private sector, public sector experiment stations originated more than a century ago. By the 1950s, most countries had established agricultural experiment stations (see Judd, Boyce, and Evenson (1986)). Most governments had also established agricultural extension programs to disseminate technical information to farmers and, in some cases, to supply inputs (see Birkhaeuser, Feder, and Evenson (1989) for a survey).

Typically, governments organize the agents involved in the production and dissemination of agricultural technology into two broad groups--researchers and extension agents. Research personnel are charged with generating improvements in crops and techniques, and extension personnel with transferring knowledge of these research products to farm households. Both services are characterized by scale economies. The theoretical paper by Dixit [26] examines the tradeoff between the scale economies obtained through specialization in a few crops and the risk reduction benefits of diversification across crops. Economies with missing risk markets cannot take advantage of the full risk reduction benefits of diversification across crops. For that reason, the advantages of specialization in a few crops to take advantage of scale economies may be especially important.

The human capital component of research and extension services varies greatly across countries but, in general, extension personnel receive much less, and much lower quality, training than their colleagues in research. The working relationship between the two groups is often compromised by

[5]The status of U.S. law on plants and animals is reviewed in U.S. Congress, Office of Technology Assessment, 1989. Intellectual property rights for technological improvements in agricultural chemicals, animal pharmaceuticals, and farm machinery are discussed by Evenson (1990).

differences in their terms and conditions of service and incentive structures. The typical pattern is that (a) research personnel have the best information on available technologies; (b) it is shared very imperfectly with the intermediary extension services, and (c) the farmers have the least adequate base of information of the three groups.

The communication problems between extension agents and farmers have many causes. Farmers may resent the salaried status of extension agents. Extension agents may be disproportionately chosen from the dominant groups. Professional staffs of extension services are often largely males, whereas in many communities, especially in Africa, a high (and sometimes the larger) proportion of farm decision makers is female. In some cultures, it is a social taboo for a male outside the household to approach individual females in a direct manner, with obvious consequences for the ability of a male extension agent to provide information.

There are also problems of information flow in the opposite direction -- from the farmers to the extension agent and up to the research staffs. The remote and typically elite members of the research staff may be too distant from the farmers' circumstances they are intended to improve. As a result, their research priorities may not reflect farmers' greatest needs, and techniques developed by farmers may not transmitted to researchers. Farming systems research (FSR) was designed in the 1960s and '70s by international agricultural research centers in a number of LDCs, including Colombia, Mexico, the Philippines, and Syria, to narrow the gap between the farmer and the research and extension services. The institutional innovation in FSR was to foster team work in diagnosing farmers' technological and related problems and in developing and testing solutions.

Implementation of this approach has been widespread, but its high cost and mixed success leaves unclear whether FSR is on balance beneficial (see Anderson, 1991).

An innovation in the delivery of extension, initiated in Turkey and later adopted in parts of Asia, Africa, and Latin America, is the *training and visit (T&V) system*. Its implementation in India is the subject of the case study by Feder and Slade [28]. In this system, extension agents play only a technical assistance role, providing agronomic information but <u>not</u> providing inputs or assisting the poor. Feder and Slade suggest that the more specialized service has the critical advantage that agents' technical knowledge is greater and their work effort is more easily monitored than it is in the less specialized extension services.

Specialization of function also helps avoid the distortion of incentives that arises in the less specialized extension services. The following example is typical of a major extension problem in parts of Asia. An extension agent, whose job it is to provide inputs as well as information, dispenses credit that is tied to pre-packaged inputs that have been designed for land type A, but not types B and C. Farmers cultivating land types B and C are "persuaded" to adopt the package by extension agents who are evaluated by their level of meeting the adoption targets. Such perverse incentives could be avoided it it were feasible to evaluate extension agents on the basis of output growth in a region.

Case Study of Palanpur, India

The final case study by Lanjouw and Stern analyzes the distribution of incomes and landholding in the north Indian village of Palanpur on the basis of four surveys undertaken between 1957 and 1984. This period saw the introduction of modern cereal varieties and the growth of jobs outside the village. During the survey period there were few land sales, but bigger and better farmers took on more land from smaller farmers under sharecropping arrangements. Such arrangements are sometimes called "reverse tenancy." According to Lanjouw and Stern, it is likely that the pattern of land leases reflects the absence of a market for farm managers and the high cost of, and small landholders' limited access to, credit.

By 1974/75, almost all the village land was irrigated and use of high-yielding wheat varieties was widespread. This was accomplished with little help from government in the form of credit, insurance, or extension.

As noted by Bell [9], Indian credit markets and related market interlinkages range along a continuum from competitive to monopolistic. Location on this continuum influences how technological change affects the distribution of income. Palanpur is on the competitive market end of the continuum. This helps to explain the encouraging result, documented in detail by Lanjouw and Stern, that agricultural intensification in Palanpur occurred broadly over the entire size distribution of farms and led to increases in incomes over the entire income distribution. de Janvry and Sadoulet's case study of Colombia [16] provides a contrasting case, in which Green Revolution technology benefitted mostly large farmers because the institutional environment (public subsidies and access to markets) was highly skewed in their favor. These two case studies bear out the critical role of advances in agricultural technology in driving change in rural societies, and the fact that their impact on income distribution depends on the organization of the rural sector.

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